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(54) Deflection device for laser beam in thermal surface treatments of splined pieces

(57) A deflection device (1) for deflecting a laser beam (2) for carrying out thermal surface treatments on splined elements (3) comprises two mirrors (11, 12) rotating at the same speed about a respective axis (13,14), and optionally a mirror (15) stationary in an intermediate position. The mirror (11,12) are inclined at a predetermined angle to their respective shafts (13,14). The inclination of the rotary mirrors (11,12) may be adjustable relative to the respective axis, as well as the relative phase of each mirror, so that the laser beam at the outlet of the device (1), describes a squashed annular trajectory (24) substantially comparable to a straight line segment.

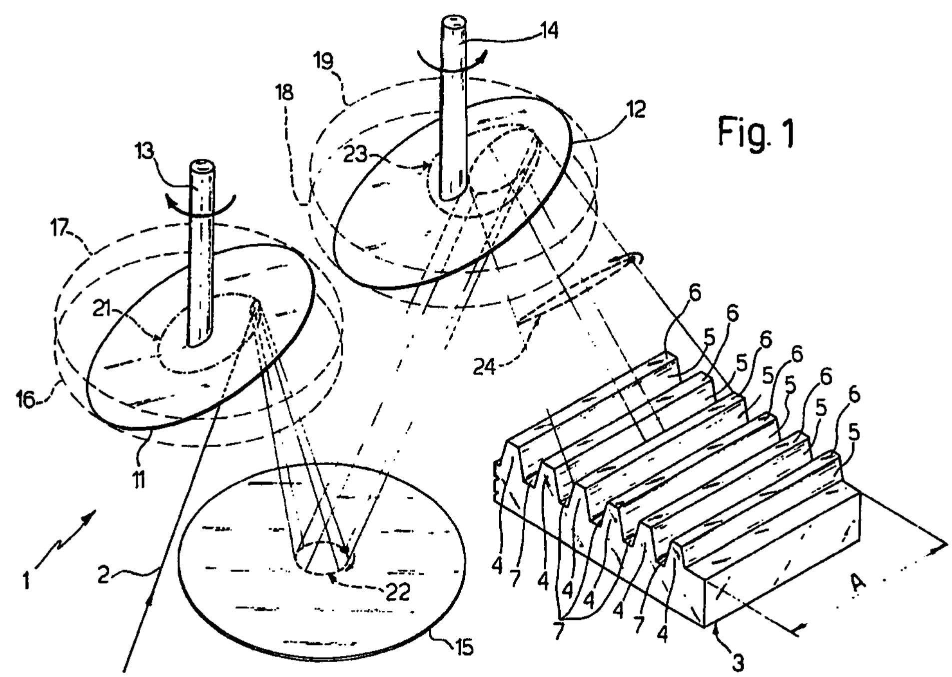

Fig. 1

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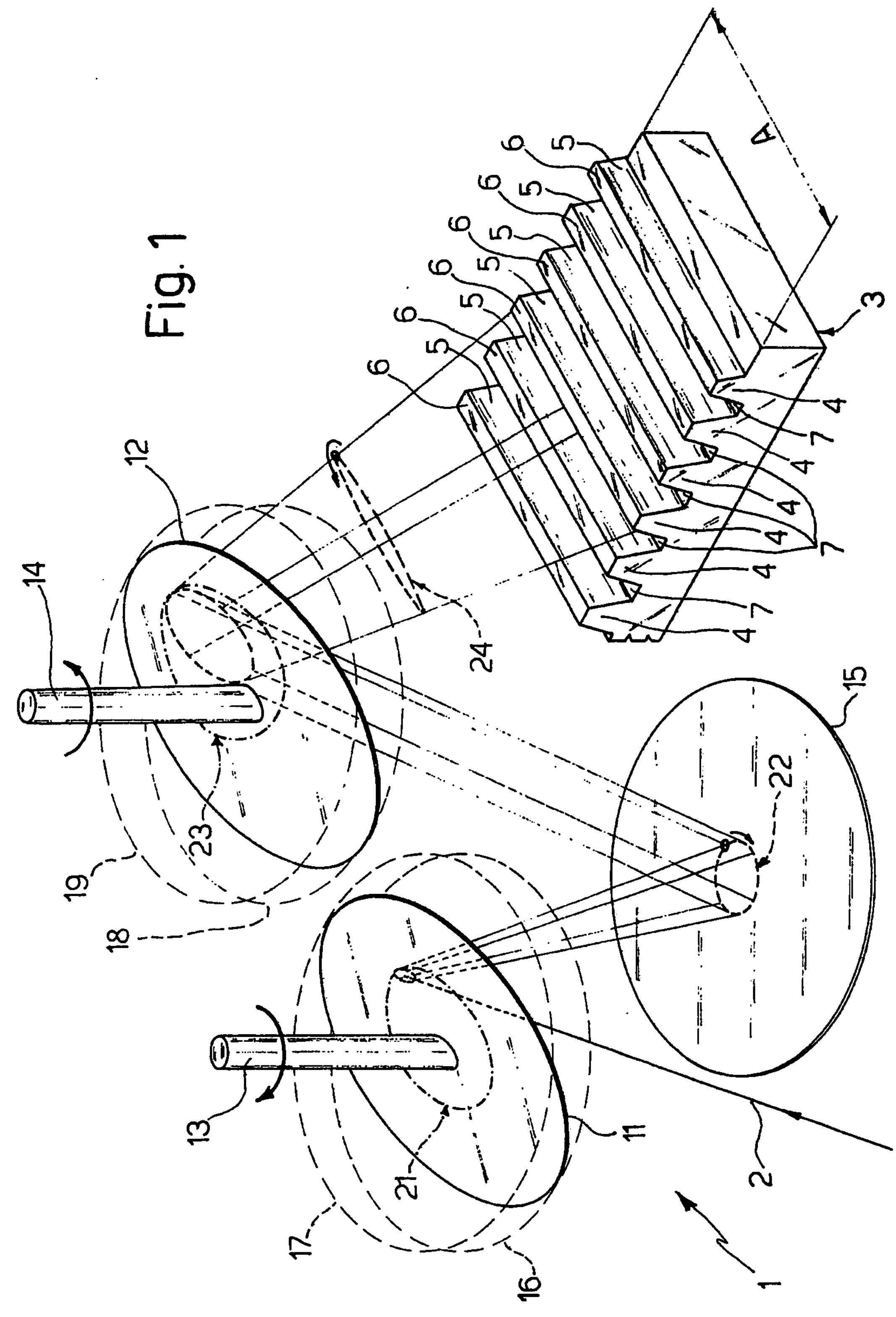

Fig. 1

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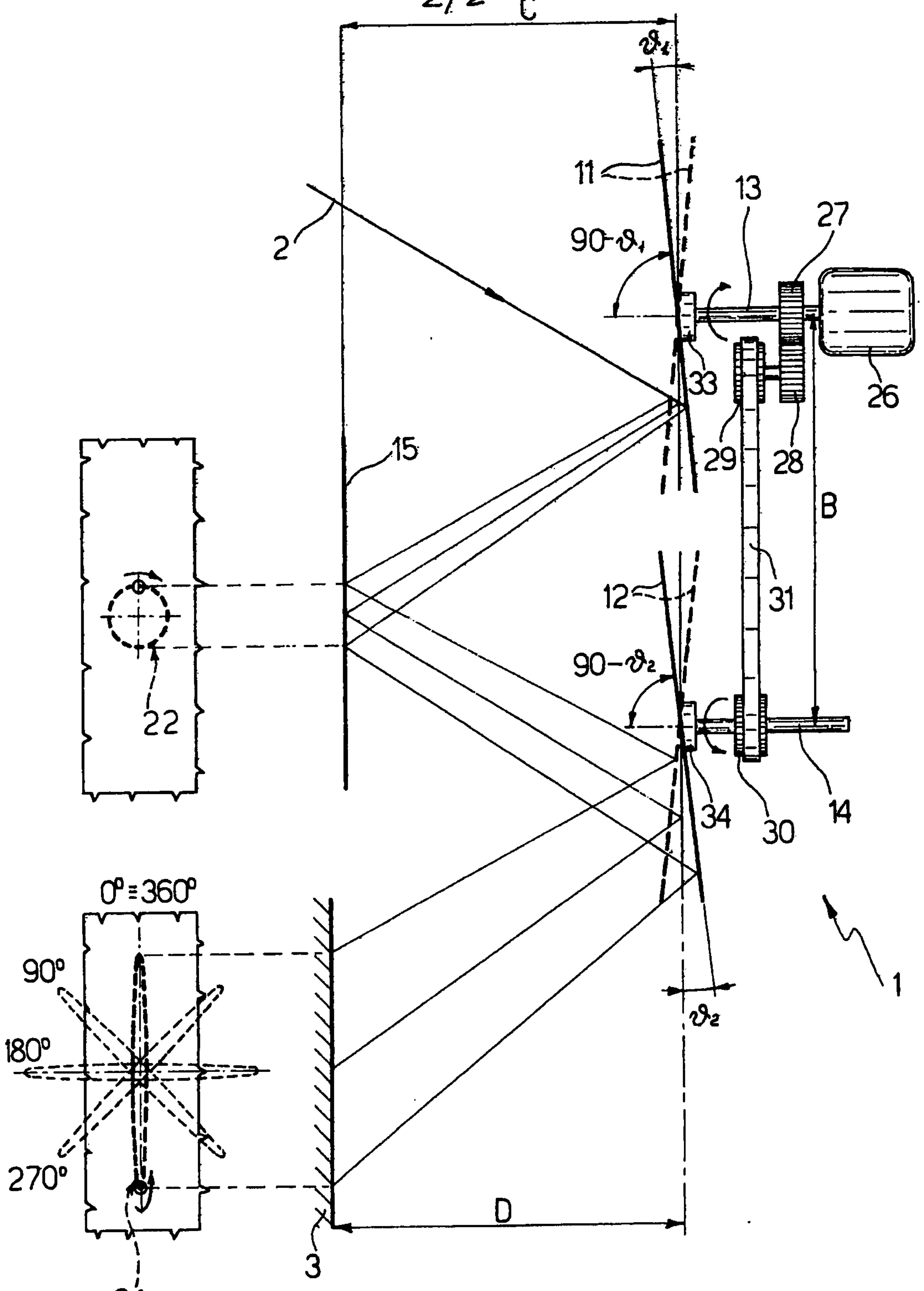
C
ϑ_1
11
13
27
2
$90-\vartheta_1$
33
26
29
28
15
B
31
12
$90-\vartheta_2$
22
34
30
14
$0^0 \equiv 360^0$
90^0
180^0
270^0
1
ϑ_2
D
3
24

Fig. 2

SPECIFICATION

Deflection device for deflecting a laser beam in thermal surface treatments of splined pieces

The present invention relates to a deflection device for deflecting a laser beam in thermal surface treatments of splined elements, i.e. elements whose zones intended to be subjected to the treatment have a substantially rectangular or similar configuration. By way of example, such elements may be gear wheels, splined shafts, homokinetic couplings and the like, and have working zones which require a localized increment of their wear resistance relative to the adjacent zones.

Since the zones to be subjected to the treatment generally have, as already said before, a rectangular configuration, and since the laser beam generated by the source of emission has preferably a circular cross-section, deflection devices have been constructed which are capable of converting the zone of propagation of the laser beam from substantially circular to substantially rectangular. To this end it is known to use a rotary prism having a plurality of reflecting lateral faces. In particular, the laser beam impinges with a predetermined angle of incidence on the lateral surface of the prism which, by rotating about its own axis deviates the beam so as to make it describe a segment whose length depends on the distance between the prism and piece being treated and on the number of faces which form the lateral surface of the prism. It has been observed that the rotating prism is particularly expensive, cannot be used for high power laser beams (more than 500W) and not suitable for carrying out treatments on zones whose amplitudes are very different from each other. Moreover, it does not allow to treat zones of very reduced amplitude, because in such a case it should be provided with a great number of faces, and this involves considerable manufacturing difficulties.

It is also known to use oscillating mirrors by means of which the laser beam is deflected so as to give rise to the cycling sweeping of a substantially rectangular zone. The known methods used to produce the oscillation of the said mirrors involve the use of magnetic field deflection systems, which are not able to guarantee a sufficiently stable extended use of the oscillating mirrors.

It is an object of the present invention to provide a device for deflecting a laser beam, which will substantially reduce or overcome the disadvantages of the known devices mentioned hereinabove and at the same time will allow being manufactured by simple, reliable and economical means.

The said object is attained by the present invention which relates to a deflection device for deflecting a laser beam in thermal surface treatments on splined elements, characterized in comprising a first mirror on which it is arranged to impinge a laser beam generated by a repective source, and at least a second mirror on which the laser beam reflected by the said first mirror impinges and from which it is reflected so as to be directed towards a predetermined zone of the said splined element which has to be subjected to the said thermal surface treatment; the said first and second mirrors rotating during use with the same angular velocity about a respective axis of symmetry relative to which each of them is mounted inclined by an angle of predetermined value so that the laser beams impinging on the said first and second mirrors will describe an annular trajectory on the surface of these latter, whilst the laser beam which strikes the said predetermined zone of the said splined element will described and oblate annular trajectory substantially similar to a straight line segment.

For a better understanding of the present invention a preferred embodiment therof will now be described by way of non limiting example with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic perspective view of a device according to the present invention, and

Figure 2 is an elevational view of the device of Fig. 1, with some structural details.

Referring now in particular to Fig. 1, reference numeral 1 indicates a deflection device for deflecting a laser beam 2 for carrying out a thermal surface treatment on a splined element 3. In the example shown, the element 3 is formed by a rack having a series of teeth 4 which are parallel to each other and extend transversally through a section whose amplitude is indicated by "A". Each tooth 4 has two lateral surfaces 5 joined at the upper end by a top surface 6; whilst between adjacent teeth 4 there are radiusing surfaces indicated by reference numeral 7.

According to the present invention, the device 1 comprises a first and a second mirror 11 and 12 respectively, which are rotated by a respective support shaft 13, 14, and a stationary mirror 15 which receives the laser beam reflected by the mirror 11 and reflects this beam towards the surface of the mirror 12. Each mirror 11, 12 is partially inclined with respect to the corresponding shaft 13, 14, so that the opposed edges of the mirrors 11 and 12 each describe, during a rotation of 360°, two circumferences indicated respectively by reference numerals 16 and 17 for the mirror 12 and by reference numerals 18 and 19 for the mirror 12. Thus, the zone in which the reflection of the laser beam 2 takes place, as regards the mirrors 11 and 12 results in being comprised between the planes defined by the circumferences 16 and 17 and 18 and 19, respectively. In particular, as regards the mirror 11, the beam describes on the surface of this mirror, an annular trace indicated by reference numeral 21. Owing to the variation of the level of the plane of reflection during the rotation of the shaft 13, the beam 2 describes on the surface of the mirror 15 a trace in the form of a circumference. In particular, the beam 2 is indicated by a small circle which migrates clockwise along the said trace 22 at the same speed of rotation as the shaft 13.

From the mirror 15 the beam 2 is reflected onto the surface of the mirror 12 and covers a zone which includes substantially all the points situated between the circles delimited by circumferences 18 and 19 and

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

the annular crown defined by the reflection of the circular trace 22 from the said mirror 15. In this way, the beam 2 describes on the surface of the mirror 12 an annular trace 23 due to the combination of the relative movement of the beam 2 and the shaft 14. By making the shafts 13 and 14 rotate in opposed directions and with a relative predetermined phase, it is possible to obtain that the laser beam reflected by the mirror 12 describes a strongly squashed annular trajectory indicated by reference numeral 24 in Fig. 1, which trajectory may substantially be compared to a segment of a straight line.

In Fig. 2 there are shown substantially all the parts of the device 1 which have been described with reference to Fig. 1. In particular, it can be noticed that the rotation of the shaft 13 is controlled by a motor 26 which, by means of four gears 27, 28, 29 and 30 and a belt 31 transmits, in a known manner, the movement to the shaft 14 therby making this latter to rotate in the opposite direction with repect to the shaft 13, as has been specified hereinabove.

The coupling between each shaft 13, 14 and the respective mirror 11, 12 is obtained by means of a respective attachment unit indicated generally by reference numerals 33 and 34 which accomplishes both the function of allowing the adjustment of the angle (90 - θ_1, and 90 - θ_2) which each reflecting surface of the mirror 11, 12 forms with the axis of the respective shaft 13, 14, and the function of adjusting the relative phase between the mirrors 11 and 12, allowing at least one of them to be positioned with a predetermined angle with respect to the corresponding shaft 13, 14.

In Fig. 2 there are indicated by "B", "C" and "D" respectively the distance between the shafts 13 and 14; the distance between the central point of the mirror 11 and the surface of the mirror 15; and the distance between the central point of the mirror 12 and the surface of the element 3. Finally, at this latter there are indicated, besides the trace 24, also some possible traces which the beam 2, reflected by the mirror 12 may describe on the surface of the element 3. In particular, by the side of each trace (shown by thin dashed lines) there is indicated a number (0°; 360°; 90°; 180°; 270°) which corresponds to the relative phase of the rotary mirrors 11 and 12.

The operation of the device 1 is quite simple. First, of all, the shafts 13 and 14 are made to rotate preferably at a constant speed. Therefore, as can be clearly seen in Fig. 2, the laser beam 2 impinges on a surface of the mirror 11 which moves sinusoidaly between a maximum and a minimum value about the distance indicated by "C". Accordingly, on the mirror 14 is formed the trace 22 along which the beam 2 runs in the clockwise direction at the speed determined by the motor 26. Analogously to what has been described hereinabove with reference to the mirror 11, the surface of the mirror 12 also moves according to a sinusoidal type law but in a rotational direction opposed to that of the mirror 11. In particular, in the case in which the displacements of the reflecting zone of the mirror 11 covered by the beam take place according to a sinusoidal law and the displacements of the analogous zone of the mirror 12 which is covered by beam take place according to a cosinusiodal type law, it is obtained that the combination of the reflections gives rise substantially to a straight line segment which corresponds to the segment 24 shown in Fig. 2. The amplitude of such segment may be adjusted by acting on the attachment units 33, 34 so as to vary the angles θ_1 and θ_2, whilst the position which this segment assumes is adjusted by acting, as said before, on the relative phase of the mirrors 11 and 12 by means of the adjustment units 33 and 34.

After having determined the orientation and the dimension of the segment 24, it is possible, with reference to Fig. 1, to determine the exact position of the segment relative to the element 3 by displacing the device 1 relative to the element 3 or vice versa, so as to make the length of the segment 24 coincide with the length "A" of the zone intended to be subjected to the treatment.

From the analysis of the characteristics of the device 1 conceived according to the teachings of the present invention the advantages which may be obtained are clearly apparent.

First of all, the device 1 is extremely flexible in that it allows to adjust in a simple way both the amplitude and the orientation of the squashed annular trace 24. Furthermore, the performances of the device 1 are stable in the course of the time; because, indeed, they depend solely upon the geometry of the system and upon the good operation of the mechanical parts (gears, belt) or the electrical parts (motor) which form the actuating portion of the device itself. It has also been noticed that the distribution of the power along the segment or annular trace 24 presents slight peak values at the ends and this results in being particularly advantageous in the case in which elements like those shown in Fig. 1 have to be treated. In fact, at the ends of the teeth 4 there is present a higher dispersion of heat, so that to obtain a uniform treatment it is necessary to supply more thermal energy at such ends.

Finally, it is clear that modificatiions and variations may be made to the device 1 described hereinabove, without departing from the scope of the invention. For example, the presence of the stationary mirror 15 is not essential, inasmuch as it is possible to displace directly to its place the mirror 12, provided all the conditions of rotation and inclination specified hereinabove are observed.

CLAIMS

1. A deflection device for deflecting a laser beam for carrying out thermal surface treatments on splined elements, characterised in that it comprises a first mirror on which it is arranged to impinge a laser beam generated by a respective source, and at least a second mirror on which the laser beam reflected by the said first mirror impinges and from which it is reflected so as to be directed towards a predetermined zone of the said splined element which has to be subjected to the said thermal surface treatment; the said first and second mirrors rotating during use with the same angular velocity about a respective axis of symmetry relative to which each of them is mounted inclined by an angle of predetermined value; so that the laser beams impinging on the said first and second mirrors will describe an annular trajectory on the surface of these latter, whilst the laser beam which strikes the said predetermined zone of the said splined

element will describe an oblate annular trajectory substantially comparable to a straight line segment.

2. A device as claimed in claim 1, characterized in that it comprises adjustment means for adjusting the said inclination of each said mirror relative to the respective axis of rotation.

3. A device as claimed in claim 1 or 2, characterized in that it comprises adjustment means for adjusting the relative phase between the said first and second mirrors.

4. A device as claimed in any of the preceding claims, characterized in that it comprises a third mirror which receives the laser beam reflected by the said first mirror and reflects the said beam onto the surface of the said second mirror.

5. A device as claimed in claim 4, characterized in that the said first and second mirrors are made to rotate by two respective shafts parallel to one another, and that the said third mirror is in an intermediate position and forward with respect to the said first and second mirrors.

6. A deflection device for deflecting a laser beam for carrying out thermal surface treatments on splined elements, substantially as hereinbefore described with reference to the accompanying drawings.

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